THE

AMERICAN JOURNAL

OF THE MEDICAL SCIENCES

FOR APRIL, 1885.

ARTICLE I.

MEMBRANOUS CROUP; DIPHTHERITIC CROUP; TRUE CROUP.

By J. LEWIS SMITH, M.D., Clinical Professor of Diseases of Children in Bellevue Hospital Medical College, New York, etc. etc.

THE term pseudo-membranous laryngitis, or laryngo-tracheitis, or true croup is applied to a common and fatal disease, the essential anatomical character of which is inflammation of the larynx, or larynx and trachea, with the formation of a pseudo-membrane upon its surface. It occurs most frequently between the ages of two and twelve years, but infancy after the age of six months and early manhood are not exempt from it. For brevity I shall use the term croup in the following pages to indicate this form of inflammation, although recognizing another form of croup, the spasmodic or catarrhal, in which no pseudo-membrane occurs.

Etiology.—Wherever diphtheria prevails as an endemic or epidemic, it is well known that a large majority of the cases of membranous croup are local manifestations of this disease, and this inflammation is therefore in such localities commonly designated diphtheritic croup. Physicians have endeavored to discriminate between croup due to diphtheria and that from other causes; but whatever the cause, the anatomical characters, the clinical history, and the required treatment are so nearly identical that attempts to differentiate the disease when produced by other agencies than diphtheria from that due to diphtheria, have proved futile and unsatisfactory in localities where diphtheria occurs, except in a few instances, as, for example, when croup has been manifestly caused by swallowing or inhaling some irritating agent.

Inflammation of the laryngeal and tracheal surface, whatever its cause, whenever it reaches a certain grade of severity, may be attended by the exudation of fibrin and the formation of a pseudo-membrane, but such a result more frequently occurs in the inflammation caused by diphtheria than in that produced by other agencies. In diphtheria a moderate laryngo-tracheitis is attended by the pseudo-membranous formation.

The percentage of cases of diphtheria in which the larynx becomes implicated and croup occurs, varies in different epidemics and in different seasons and localities. In epidemics of a mild type, the cases appear to be fewer in which the larynx is involved than in epidemics of a severe form. In New York the percentage is large. From December 1, 1875, to July, 1878, I preserved records of all the cases of diphtheria which came under my notice. The number was 104, and in twenty-five of these, or about one in four, croup occurred, producing the usual obstructive symptoms, and constituting the chief source of danger. During the two and a half years embraced in these statistics the disease was usually severe. In the last five years amelioration has occurred in the type of diphtheria in this city, and the proportion of croup cases has not been so large.

So commonly is membranous croup, when occurring in a locality where diphtheria is endemic or epidemic, a local manifestation of diphtheria, that physicians in such localities come to regard every case of this disease of the larynx as produced by the diphtheritic poison. In New York physicians scarcely recognize any other form of membranous croup. It is well, therefore, briefly to recall the evidences that croup in a certain proportion of cases results from other causes than diphtheria. The occurrence of croup in localities where diphtheria is unknown, of course, indicates the operation of some other agency than the diphtheritic poison. Thus, in 1842, before diphtheria was established in this country, Dr. John Ware, of Boston, published his well-known paper on croup, and in 74 of the 75 cases embraced in his statistics the membranous exudation was present upon the faucial surface. The statistics relating to the introduction of diphtheria into New York City, and the recorded death statistics of this city, have been annually published, and each year more or fewer deaths from croup have been reported. The first death from diphtheria in this century, within the city limits, certified by a physician, was that of a German woman, at 638 Hudson Street, on February 15, 1852. Two other fatal cases occurred in 1857, and since then the deaths from croup and diphtheria have been as shown in the following table:—

Year.	Croup.	Diphtheria.	Year.	Croup.	Diphtheria.
1858	478	5	1867	338	251
1859	622	53	1868	342	276
1860	599	422	1869	483	328
1861	460	453	1870	421	308
1862	685	594	1871	466	238
1863	908	981	1872	675	446
1864	754	781	1873	732	1151
1865	449	534	1874	594	1665
1866	368	435	1875	758	2329

Since 1875 weekly bulletins were issued instead of the annual reports.

Thus, in the first years after the introduction of diphtheria, the deaths assigned to croup so greatly outnumbered those of diphtheria, as in 1858, when five died of diphtheria and four hundred and seventy-eight of croup, that it is evident that most of the cases of croup in those years were attributable to other causes than diphtheria. Since, as we have stated, any inflammation of the surface of the larynx and trachea, if sufficiently intense, may produce a pseudo-membrane, croup may occur as a primary disease, and as a complication of various maladies. According to my observations in New York City, the chief causes of croup, arranged in the order of frequency, would be about as follows: diphtheria, "taking cold," measles, pertussis, scarlatina, typhoid fever, irritating inhalations. I have, elsewhere, related cases of scarlet fever of severe type, in which a thin film of pseudo-membrane was found upon the surface of the larynx and trachea, and there was no other lesion to indicate that diphtheria had supervened. The croup was, to all appearances, caused by the scarlatinous and not the diphtheritic poison. The following was a case in which croup was apparently idiopathic, and produced by that common cause of inflammations of mucous surfaces, to wit, exposure to sudden atmospheric changes:—

Case.—At midnight, on October 22d, 1884, I was summoned to a child aged 25 months, who had been in the street till nearly nightfall, when the weather suddenly became much cooler, and he was brought home. At 11.45 P. M. he awoke with a harsh voice and croupy cough so as to alarm the family. I found the axillary temperature normal, but the fauces were injected, and the diagnosis was made of spasmodic or catarrhal croup. Emesis was produced by syrup of ipecacuanha; the croup kettle, and a mixture of potassium chlorate and ammonium chloride were ordered.

On the following day he walked around the room and seemed better, but the inhalation of the vapor of lime from the croup kettle was continued. At 7 P. M. the symptoms became aggravated, the cough was frequent and hoarse, temperature (axillary) 100½°, pulse 120, and respiration noisy. At my visit the post-clavicular, supra-sternal, infra-mammary, and epigastric regions were depressed in each inspiration, though only in a moderate degree; face flushed, fauces injected but without pseudo-membrane. The aspect was now more serious on account of the increasing dyspnœa. The pulse was strong, and no pseudo-membrane was visible; the temperature, in the groin, was scarcely 100°. Emesis had been produced before my arrival, and in the matter vomited was a pseudo-membrane with ragged edges, and about one-half an inch in length; examined within an hour subsequently under the microscope, it was found to consist of fibrillæ, evidently fibrous, some of them wavy, and inclosing many pus-cells. Ten grains of calomel were placed on the tongue, and inhalations of the following were almost constantly employed by the steam atomizer:—

℞.—Liq. potassae, ʒij;
Aq. calcis, ℥xij. Misce.

On the following day the respiration was easier, and within twenty hours the patient had so far convalesced as to be out of danger. There had been no case of diphtheria in the house, nor recently, as far as I could learn, in the immediate neighborhood.

That this was a local disease, non-specific, and quite distinct from the croup of diphtheria, cannot, I think, be doubted.

In considering the etiology of croup, and recognizing diphtheria as by far its most common cause, wherever the latter disease prevails, an interesting theory is suggested, to which Heubner alludes, who affirms that inflammations, even with the characteristic membranous exudation, may be set up without the micrococci and then inoculation by micrococci occur, and "induce the general disease" ("Die experimentelle Diphtheria," Leipzig, 1883, quoted in Ziegler's *Path. Anat.*, part ii. paragraph 444, Wm. Wood & Co., 1884). The point alluded to is that inflammations arising from other causes than diphtheria now and then become intensified, and rendered more protracted and dangerous by the reception of the diphtheritic virus after the inflammations are established. In support of this opinion it is well known by all who have had much experience with diphtheria, that those surfaces are prone to be attacked by the specific inflammation that are already irritated or inflamed when diphtheria is contracted. Hence the occurrence of the pseudo-membrane on recent wounds, upon the eyelids in cases of catarrhal conjunctivitis, upon the uterine surface after parturition, and upon the laryngeal, tracheal, and bronchial surfaces, if they are already inflamed as in measles.

Scarlatina is so often complicated by diphtheria that there seems to be a close affinity between the two diseases. It is a very common observation in New York city that scarlet fever continues two or three days, in its usual form, when the symptoms become suddenly aggravated and the aspect of the disease more severe. On inspecting the fauces a pseudo-membrane is discovered covering this region, and it probably appears also upon the nasal surface. Although severe scarlatinous inflammation may cause a fibrinous exudation, yet that diphtheria has supervened upon scarlet fever in a considerable proportion of cases which have the above history cannot, I think, be doubted. In a few instances in my practice (4) the fact that scarlet fever was complicated by true diphtheria, and the scarlatinous inflammations, first in order, were intensified by the presence and influence of the diphtheritic poison, was shown by the occurrence of diphtheria without scarlet fever in other members of the family.

In accordance with the above law we may assume that a child who has laryngo-tracheitis, so common from taking cold and manifested by cough and hoarseness, is more prone to have diphtheritic croup than is one whose air-passages are in their normal state when diphtheria commences. A supposed error of diagnosis is often made by physicians, always to their discredit, who diagnosticate catarrhal laryngitis, but find, after two or three days, that their patients really have diphtheritic croup. A considerable number of such instances have come to my notice, always with the ill-will of families towards their physicians. Now it seems to me that in many of these cases the physicians have been right in their first diagnosis, and diphtheritic croup supervened on the catarrhal inflammation.

Another point relating to the etiology of diphtheritic croup requires notice. Many physicians, who have had ample opportunities to observe diphtheria, believe that the common way in which diphtheritic croup begins is as follows: The faucial or nasal surface is first affected, becoming covered by the pellicular exudation, and during inspiration particles of the pseudo-membrane, containing the specific principle, being detached, lodge in the larynx. At the point of inoculation the specific inflammation arises and extends. This may be the manner in which the croup of diphtheria begins in certain cases, but it certainly does not apply to a considerable number of patients. Thus both the faucial and nasal pseudo-membranes may be treated every second or third hour from the time of their formation with the best disinfectants which we possess, so as to destroy all the micrococci in them and render them an inert mass, and yet croup not infrequently occurs during the progress of the case. Again, in certain cases croup begins at the commencement of the diphtheritic attack. The laryngitis commences as early as the pharyngitis, and therefore does not result from it. Sometimes the inflammation of the air-passages is from the first the predominant lesion, the pharyngitis being subordinate or even trivial. Thus a boy of two years, ten months, whom I attended, died of croup lasting about four days. He lived in the suburbs of the city, where the houses were scattered, and where there had been no recent diphtheria. The attack began with hoarseness, which gradually increased to a fatal obstruction in the air-passages. Close and repeated inspection of the fauces revealed only redness and some swelling of the parts that were visible, and the symptoms indicated but slight coryza. The diphtheritic nature of the disease was rendered certain by the occurrence of diphtheria in its usual form, in the two nurses immediately after the death of the child. In this case croup began at the beginning of the sickness, and it is evident from the history and the lesions that the contagium was not transferred to the larynx from any of the other surfaces. In view of the number of such cases I see no propriety in assigning to diphtheritic croup a mode of origin different from that of other diphtheritic inflammations. But the possibility, and perhaps, probability, in some instances of an auto-infection we will not deny.

Anatomical Characters.—It is important to acquaint ourselves with the anatomical characters of croup, especially with the nature of the pseudo-membrane, that we may know what measures to employ in order to remove it and prevent, as far as possible, the laryngeal stenosis from which so many perish. The surface of the larynx, trachea, and, in severe cases, that of the bronchial tubes, is hyperæmic and swollen, and the inflammatory action involves more or less the submucous connective tissue, causing infiltration or œdema. The relation of the exudation to the mucous surface varies according to the kind of epithelium present. Where the epithelium is of the flat or squamous variety, the fibrinous exudation from the bloodvessels is poured out around the epithelial cells, which perish. If the inflammation extend more deeply, the underlying connective tissue is also embraced in the coagulation and perishes. Prof. Ziegler of Tübingen, who has made repeated microscopic examinations of the pseudo-membrane, says: "It sometimes happens that the dead epithelial cells become saturated with the exuded liquid and then pass into a peculiar condition of rigidity akin to coagulation. The seat of this change appears to the naked eye as a dull, raised, grayish patch surrounded by red and swollen mucous membrane. The exudation is rich in albumen and the transformed cells take on the appearance of a kind of coarse mesh-work, almost or altogether devoid of nuclei." This is superficial diphtheritis, and Prof. Ziegler next describes deep or parenchymatous diphtheritis as follows: "It is characterized by the coagulation, not merely of the epithelium, but also of the underlying connective tissue. The affected patch is swollen and assumes a whitish or grayish tint, the discoloration extending through the epithelium to the connective tissue structures. The epithelium in some cases is lost altogether, and then the diphtheritic patch consists of dead connective tissue only. . . . The dead tissue is separated from the living by a zone of cellular inflammation. Fibrinous filaments are seen here and there through the mass. The lymphatics in the neighborhood contain coagula and leucocytes."

Squamous epithelium covers the nostrils, buccal cavity, fauces, the larynx upon and above the superior vocal cord, with the exception of its anterior aspect. The pseudo-membrane therefore upon all these surfaces lined with this form of epithelium consists of the exudate from the blood which surrounds and permeates the epithelium, or epithelium and subjacent connective tissue. These two distinct elements, that poured out from the bloodvessels and the normal tissue of the mucous surface now dead, incorporated in one mass, therefore constitute the pseudo-membrane. Its intimate relation with the surrounding living tissue is such that we cannot detach it without lacerating the latter and causing bleeding.

The anterior aspect of the larynx from the middle of the epiglottis downward, all that part of the larynx below the superior vocal cord, the entire trachea, and the bronchial tubes, are lined by columnar epithelium. Whenever this variety of epithelium is present, the exudate from the blood does not become incorporated with the mucous membrane, but escapes to the surface and coagulates in a layer over it. It is therefore loosely adherent to the underlying tissues, being attached to it by some fibrinous threads, and when it is peeled off, the hyperæmic and swollen mucous membrane is seen underneath in its entirety, unless, as is commonly the case, a considerable part of its epithelium has been shed and been expectorated. The loose attachment of the pseudo-membrane in the trachea and bronchial tubes is of the greatest significance in its relation to tracheotomy.

I wish in this connection to call attention to the confusion which may occur in the use of the terms diphtheritic and croupous, as employed by pathologists on the one hand, and clinical observers or practitioners on the other. Pathologists, following Virchow, designate the inflammation diphtheritic when the epithelium and underlying tissues remaining *in situ* are blended with the exudate and become a part of the pseudo-membrane, whatever may be the cause of the inflammation, and they designate the inflammation croupous, whatever its cause, when the exudate escapes to the surface of the mucous membrane, as in the trachea and bronchial tubes, and coagulates upon it. Therefore, in all cases of pseudo-membranous inflammation of the air-passages, even that due to "taking cold," or to inhalation of an irritating vapor, they term the laryngitis diphtheritic, since in the larynx the exudate is incorporated with the mucous membrane, while the pseudo-membranous tracheitis or bronchitis in the same patient is termed croupous, since the exudate lies upon the surface. Practitioners, on the other hand, apply the term diphtheritic to all inflammations which occur as local manifestations of the specific disease, diphtheria, and only to such inflammations, whatever may be their form, whether pseudo-membranous or catarrhal.

The epithelial cells embraced in the pseudo-membrane undergo a histological change. We have stated Ziegler's remark that they are permeated by the exudate of the blood. Cornil and Ranvier say, "Wagner admits the fibrinous degeneration of the cells. . . We have verified the description given by Wagner, but we would conclude that the cells are filled with a material which approaches mucin rather than fibrin." In the first week, the pseudo-membrane forms more rapidly, and is usually thicker and more extended, producing dyspnœa more quickly than when it forms in the declining stage of the disease. If the membrane be detached by the forcible coughing of the patient, it is usually quickly reproduced unless the diphtheria be in its advanced stage and abating. If the croup continue from four to six days, the pseudo-membrane begins to soften from commencing decomposition and to disintegrate. The minute fibres which attach it to the membrane give way, and in favorable cases by the effort of coughing or vomiting it is thrown off. Separation is aided by the muco-pus which collects underneath.

Symptoms.—Whenever croup is one of the local manifestations of diphtheria, such general or constitutional symptoms are present as pertain to this blood disease, such as febrile movement, anorexia, thirst, and progressive loss of flesh and strength. The temperature in the commencement in croup from this cause is usually higher than at an advanced period, unless some complication occur, as pneumonia, which increases the heat of the system. The temperature is not, however, in the beginning, ordinarily above 103° or 104°, and, as the croup continues, and the systemic blood-poisoning becomes more marked, the temperature usually falls, so that, even in the gravest cases, it is often at or below 100°. Most patients also have those inflammations which commonly attend diphtheria, *i. e.*, pharyngitis and more or less coryza, but they are relatively unimportant in comparison with the croup, for, unlike the croup, they do not in themselves involve immediate danger to life.

Croup commonly begins gradually and insidiously, revealed at first to the physician by hoarseness or huskiness of the voice, and a hoarse or harsh cough. Both voice and cough are feeble, lacking the fulness and sonorousness present in spasmodic laryngitis. In grave cases, approaching a fatal termination, the voice becomes more and more indistinct, and finally is suppressed. The cough, also, which in the beginning of the croup was strong and expulsive, becomes feeble and ineffectual, and less frequent as the fatal result draws near.

The amount of sputum varies considerably in different cases. If the inflammation extend no further downward than the trachea it is scanty, but if there be coexisting bronchitis, it is more abundant, consisting of muco-pus with occasional flakes of pseudo-membrane. By vomiting a larger quantity is expelled than by the cough. Occasionally masses of pseudo-membrane of considerable size are expectorated, even moulds of some part of the respiratory passage, always with great temporary relief to the patient. A pseudo-membrane of considerable thickness and extent obstructs the expectoration of muco-pus, which, collecting in the lower part of the trachea and in the bronchial tubes, greatly increases the dyspnœa. The respiration is somewhat more frequent than in health, but it is not notably increased except when bronchitis or broncho-pneumonia is present. At an advanced stage, when stupor supervenes from non-oxygenation of the blood, the respiration may be slower than in health.

Croup in its commencement and in the active period of diphtheria without treatment almost never remains stationary or abates. Little by little or often quite rapidly, the laryngeal stenosis increases, and soon the patient begins to experience the want of air. He becomes restless, has an anxious expression of the face, seeks change of position, reaching out his arms to the nurse or mother to obtain relief. In some patients only a few hours elapse and in others a day or more of gradual increase in the obstruction, when it becomes evident that death must soon occur unless relief be afforded. In this stage the post-clavicular, infra-clavicular, supra-sternal, and infra-mammary regions are depressed during inspiration, and the larynx is drawn with each inspiratory act towards the sternum. While there is constant suffering, there are also occasionally most distressing attacks of dyspnœa attended by an increase in the lividity of the features and extremities which now have an habitual dusky pallor. Sometimes these attacks are perhaps due to the doubling of a detached end of the pseudo-membrane on itself, or perhaps to a movement of the muco-pus by which bronchial tubes are occluded. With the ear applied over the larynx or upper part of the sternum, a loud rhonchus is heard both on inspiration and expiration, produced by the passage of the air over the obstruction, and obscuring to a great extent the other sounds. Moist bronchial rales are also common.

Those who recover from membranous croup without tracheotomy, and by the use of inhalations, and thus far they constitute only a small minority, usually improve gradually, the obstruction diminishing by softening and detaching of portions of the pseudo-membrane, the cough becoming looser and the voice less hoarse. After the detachment of the pseudo-membrane, several days elapse before the thickening and infiltration of the mucous membrane disappear and the epithelial cells are restored.

Diagnosis.—Catarrhal laryngitis with a usual amount of thickening and infiltration of the mucous membrane and the underlying connective tissue, so as to produce stenosis and obstruct respiration, may be mistaken for pseudo-membranous inflammation. In the N. Y. Foundling Asylum, two children have at different times died with the symptoms of membranous laryngitis, and the obstruction was found to be due entirely to the thickening and infiltration of the mucous and submucous tissues of the larynx by newly-formed corpuscular elements. Of course, death from catarrhal laryngitis is rare, but that this disease may produce such an amount of laryngeal stenosis as to cause even fatal dyspnœa, like that from the presence of pseudo-membrane, these two cases show. In most instances, the diagnosis of membranous laryngitis from catarrhal laryngitis is easy, by the presence of patches of pseudo-membrane on the fauces, or by the history of the case, which evidently points to diphtheria as the cause. I have elsewhere alluded to a child in my practice who died with the symptoms of acute laryngeal stenosis, without any pseudo-membrane upon visible parts, and with only a moderate pharyngitis. This case, which might have passed as one of catarrhal laryngitis, accompanied by an unusual amount of cellular and serous infiltration, as there was no known diphtheria in the vicinity, was really due to diphtheria, and was a local manifestation of that disease, for immediately after the death of the patient the two nurses had unequivocal symptoms of diphtheria. The difficulty in using the laryngoscope in young children is such, when their fauces are swollen, that it has not heretofore aided much in the differential diagnosis of the various forms of acute laryngeal stenosis in young children, at least when employed by the general practitioner.

Prognosis.—The mortality from croup obviously depends to a great extent on the prevalence and the type of diphtheria. From what has been stated above, it follows that croup is more frequent and more fatal in a grave form of diphtheria than in mild epidemics with a less degree of blood-poisoning. In New York City, during the fifteen years ending with 1878, the percentage of recoveries was very small, both under medicinal treatment and tracheotomy. During this long period, surgeons, not saving more than three to five per cent. of their cases by tracheotomy, performed this operation reluctantly. But since 1878 the percentage of recoveries after tracheotomy has been much greater. The mortality from croup is greater the younger the patient; for the younger the child, the less the diameter of the air-passages, and the more quickly laryngeal stenosis results. The younger the child, also, the more difficult is the use of the proper remedies, and the less the time for their use before fatal dyspnœa occurs. We have already said that croup appearing in the declining stage of diphtheria is less severe and more easily controlled or cured than when it occurs in the commencement of diphtheria. Much depends, also, upon whether the physician is summoned at the very beginning of the croup, and appropriate remedies are early and persistently employed. In many instances the friends do not take alarm, and the physician is not summoned till the disease is well under headway, and there is not the requisite time for the action of inhalations. Obviously, also, croup, beyond all other diseases, requires faithful and intelligent nurses, for without the co-operation of such nurses night and day, in the care of the patient, the most judicious measures are often rendered inefficient.

Exact statistics are lacking to show what proportion of cases of croup recover by strictly medicinal treatment. If we regard as incipient croup those cases in which the voice becomes hoarse or harsh, but no dyspnœa occurs, and the lungs are fully and normally inflated, a considerable number, I think, more than fifty per cent. in my practice recover. There may be in these cases a catarrhal laryngitis, or there may be a thin film of pseudo-membrane upon the laryngeal surface, not sufficient to embarrass respiration. Slight laryngitis, therefore, occurring in the course of diphtheria, unaccompanied by any increase in temperature, or change in the freedom or rhythm of respiration, and whose only symptom is a huskiness of voice, if treated early and properly by inhalations, passes off in a few days in a large proportion of cases. It possesses little importance except that it might be the initial stage of croup if neglected. It is obviously improper to consider this trivial form of laryngitis as membranous croup, although by neglect it might become such. In the statistics of croup, those cases only should be included in which the symptoms are so pronounced that it is evident that more or less laryngeal stenosis is present, although there may as yet be no marked dyspnœa.

In determining the percentage of recoveries in croup, it is proper to arrange cases in two groups: 1st, cases which have received only medicinal treatment; 2d, cases in which tracheotomy has been performed. Having been in almost continuous practice, since diphtheria began in New York, in a section of the city where this disease has always been prevalent, and having witnessed all kinds of treatment—that by emetics, by depletion, by stimulation, by inhalation and insufflation—it is my opinion that not more than one in eight has recovered by medicinal treatment in this long period, of cases of croup, which began in the first week of diphtheria, and in which the symptoms were so pronounced as to indicate more or less laryngeal stenosis. The exudation in the first week of diphtheria, or in its active period, occurs so rapidly, and in such large quantity, that no one of the medicinal agents or modes of treatment, which physicians commonly prescribe, is sufficiently prompt in its action to prevent the formation of the pseudo-membrane to an extent that soon endangers life. I allude to what has hitherto been the result.

Perhaps we may yet discover a mode of treatment that more effectually controls the formation of pseudo-membrane.

Croup occurring in the second or third week of diphtheria, since it is attended by less abundant and less rapid exudation than when it occurs during the acute stage, can be more successfully treated under the persevering use of solvent inhalations, and, according to my observations, a larger proportion than one in eight, perhaps one in three, recovers by the early and continuous or almost continuous use of inhalations.

Still the mortality is so large, and the suffering so great in croup, at whatever stage of diphtheria it occurs, that we cannot rely on the slow action of medicines or inhalations, and surgical treatment is in most instances required to diminish the suffering, and afford the best chances for saving life. Tubing the larynx, to which we will allude hereafter, has been so seldom performed, and the statistics of it are so meagre, that we are unable to state what proportion of patients may be saved by it. I have twice observed in the New York Foundling Asylum prompt relief from tubage, when the dyspnœa was so great as to threaten immediate death. In one of the two patients the relief was temporary, and in the other permanent. If the obstruction was confined to the larynx or larynx and upper part of the trachea, tubage would, I think, come into general use as a substitute for tracheotomy, but, unfortunately, it fails to give relief and save life in those many cases in which the obstruction extends throughout the trachea and into the bronchi. The statistics of tracheotomy, on the other hand, are abundant, and we are enabled therefore to determine to what extent it can rescue the victims of this disease from impending death. *The American Journal of Obstetrics* for May, 1868, gives the results of tracheotomy performed by Drs. Jacobi, Krackowizer, and Voss as follows:—

	Cases.	Recoveries.	Deaths.	Per cent. of recoveries.
Jacobi, Krackowizer, and Voss . . .	166	39	127	—
J. H. Ripley, N. Y. Med. Record, 1880 . .	56	16	—	—
Parisian Children's Hosp., 1851–1875 (Tenné)	4663	—	—	24
Bethanien in Berlin, 1861–1872 (Bartels) .	330	103	—	31.2
Berliner Chirurg. Klinik, 1870–1876 (Krönlein)	504	147	—	29
St. Annenspital Wien (Monti) . . .	210	—	—	33
Table of Monti from various sources . .	2608	—	—	25
Hofmohl's statistics	3760	—	—	27
Küster's statistics	1556	—	—	32
C. Hospital, Trousseau, Paris, during 1883 (per Dr. L. Enfance)	359	115	244	32
Clinic of the Zurich Kantonspitals, under Rose and F. Krönlein, 1868, Mar. 1882 (11 under 2 years, 1 of 8 months)	238	92	—	39
Deutsche Zeitschrift für Chirurg., 1882, Bd. xvii. (H. Lindner)	101	—	—	37⅔
Statistik der Tracheotomie per Croup, Deutsche Chirurger Lieferung, 37 Stuttgard, 1880, by Kühn	277	125	152	—
Hôpital des Enfants Malad., Paris, 1850–1857	389	86	—	22
Hôpital des Enfants Malad., Paris, 1860–1867	813	208	—	—
Trousseau, according to Kühn . . .	466	126	—	25
Guersant (Sédillot), Med. Oper., ii. page 480	171	36	—	21
Barthef, Hospital St. Eugenie, 1855–1868 .	573	160	—	28
Cases in the Parisian Hospitals and in the Provinces, Fascher et Bricheteau . .	1011	—	—	25
Roser (Lissard), C. C., 1854–1861 . . .	42	19	—	45.4

	Operations.	Recoveries.	Per cent. of recoveries.
Uhde, Archiv f. Klin. Chir. 1869, 1820–1869 . .	81	21	25
Max Muller (Langenb. Arch. f. Klin. Chir. vii.) .	45	15	33
Bardenheuer (Cölner Bürgerhospitals, 1875–1876) .	129	46	35.6
Krankenhause Bethanien, 1873, and following (H. Settegast)	375	119	31.75
Billroth, Chirurg. Klinik Wien., 1871–1876 . .	18	1	—
Reisz, Bronchotomicus Indicat., 1858 . . .	17	5	—
Wansher (Copenhagener Kommuni Hospitals, Sept. 1863, Dec. 1876)	400	170	42.5

The result of tracheotomy in infants is much less favorable than in older children. Dr. Gustav Chagin has published in the *Archiv für Kinderheilkunde*, Bd. iv., the statistics of cases in infancy. These cases, 977, occurred since 1874; and of this number, 832, or 85 per cent., died. In the Copenhagener Kommuni Hospital, in which, as stated above, there was the remarkably good general result of 170 recoveries in 400 tracheotomies, only 5 per cent. recovered of children under one year; of 76 operated on between the ages of one and two years, 22 recovered, or 29 per cent.; while of 296 operated on between the ages of two and ten years, 146 recovered, or 49.3 per cent. In the Krankenhause Bethanien, the results of tracheotomy from the beginning of 1861 to the close of 1876, tabulated according to the age, were as follows (H. Settegast):—

Age.	Tracheotomies.	Recovered.	Per cent.
2 to 3 years	93	22	23.65
3 " 4 "	165	47	28.45
4 " 5 "	175	54	30.85
5 " 6 "	107	39	35.45
6 " 7 "	90	34	37.77
7 " 8 "	59	17	38.86
8 " 9 "	24	11	45.83
9 " 10 "	15	6	40.00

These statistics show that the older the patient upon whom tracheotomy is performed, other things being equal, the greater the percentage of recoveries. Prof. Abraham Jacobi has probably performed tracheotomy for croup in as many cases as any other physician or surgeon in this country, not fewer, he thinks, than 400 times. His opinion corresponds with the common belief that, during the last five years, the percentage of recoveries after tracheotomy, in New York City, has been much larger than previously, and the operation is performed more frequently by the attending physician than formerly. The result of tracheotomy during a long series of years, ending with 1878 or 1879, was so unfavorable, on account of the type of the disease, that Dr. Jacobi thinks, in the aggregate of his cases of tracheotomy since 1858, only about 12 per cent. recovered.

Although at present in this city the percentage of recoveries after tracheotomy is much larger than formerly, yet the statistics of some of the prominent physicians and surgeons show nearly as large a proportion of death as in former years, probably because the operation has been deferred till the patients were nearly moribund. Thus, one surgeon records only 4 recoveries in 21 operations during the last three or four years, and a physician of large experience, connected with one of the institutions where children are treated, has been equally unsuccessful in his tracheotomies, but he has operated only when the dyspnœa was extreme, and death momentarily expected. Earlier operation might have given better results.

The statistics of recent tracheotomies, which seem to me to indicate most accurately the results of this operation when skilfully performed, and not at too late a stage in the type of diphtheria now prevailing in this city, I have obtained from Drs. J. H. Ripley and Fred. Lange. The operations embraced in their statistics were performed since January 1, 1879, with the following result:—

Tracheotomies.	Died.	Recovered.	Per cent. of recoveries.
66	44	22	$33\frac{1}{3}$

These surgeons do not select cases for the operation, but they operate on nearly every patient with croup, to whom they are summoned, provided that death seems inevitable without tracheotomy. They operate even if serious complications be present, as nephritis or pneumonia, or the blood be profoundly poisoned. With them the inducement to operate is sufficient if tracheotomy diminish the suffering, or increase the chances of recovery in however trifling a degree. Inasmuch, therefore, as they do not select cases, so good a result is noteworthy.

Some physicians in this city make greater discrimination in cases, and do not operate if the condition of the patient be such that death will in all probability occur after tracheotomy. They do not, therefore, advise the operation, if the patient have profound blood-poisoning or severe local disease elsewhere than in the air-passages. Such physicians by the early performance of tracheotomy, and by careful attention to the after-treatment, making frequent visits and supervising the details of the management, furnish more favorable statistics of the operation than any of those published above. Thus, Dr. A. R. Robinson, who makes such discrimination in cases, who operates early, does not insert the canula until all loose muco-pus and shreds of pseudo-membrane are expelled by the cough from the trachea and bronchial tubes, and who supervises by frequent visits the after-management, has saved since 1880 eleven in thirteen consecutive cases of undoubted membranous croup. It is seen from the above statistics that we can claim for tracheotomy judiciously performed, and at a sufficiently early stage, the cure of one in every three patients in the average. The statistics in Boston show that the results obtained in that city in hospital practice have been about the same as those in New York and in European cities. In an interesting paper on tracheotomy in croup, published in the *Medical News*, July 12, 1884, the writer says: "Tracheotomy for this disease has been performed one hundred and eighteen times at the Boston City Hospital during the past twenty years. Thirty-nine, or one in three, were successful. That the cases were not selected is shown by the fact that three patients died during the operation from shock and exhaustion, not from hemorrhage; thirty-four died within twenty-four hours; and fifty-six, or more than one-half of the fatal cases, within forty-eight hours. Four, if not five, of the successful cases were practically moribund at the time of the operation. . . . . The ages of these patients ranged from nine months to forty-one years. The youngest to recover was eleven months; the oldest sixteen years. Four aged two years and five aged three years got well. Membrane was visible in the fauces or trachea in a large proportion of both the successful and unsuccessful cases. Its absence was noted in only three of each class. It need not be said that in every instance there was present severe, constant, and increasing dyspnœa, exhausting the strength and threatening suffocation."

Preventive Treatment.—In attending a case of diphtheria the physician should notice at each visit whether the patient have any hoarseness or other signs indicating implication of the larynx, since, if the danger be recognized at its inception, it may perchance be averted. Ineffectual as inhalations may be for fully declared croup, we have seen in speaking of the prognosis that experience fully justifies the belief that they are sufficient in a large proportion of cases to relieve that degree of laryngitis which is indicated by simple hoarseness, and which if it continue might eventuate in serious obstructive disease. If the physician observe such symptoms, he should immediately recommend that the air in the apartment be kept moist by the croup kettle or pans of hot water over the fire, into each of which a lump of lime is placed. I frequently surround the bed with a tent made with a clothes-horse, over which blankets are thrown, and place the croup kettle underneath. Frequently stirring the water in the kettle adds to its efficiency. I prefer, however, in most instances, to employ the steam atomizer either with or without the croup kettle. It should be so constructed that it throws a heavy spray of rather turbid lime-water, and should be almost continuously used as long as the premonitory symptoms of croup continue. It obviates the necessity of heating the apartment, which in hot weather is very uncomfortable.

It is proper in this connection to consider which is the most efficient and the best agent for inhalation in croup. Have we an agent that can be safely used, which will prevent, when inhaled, the formation of the pseudo-membrane, or which will dissolve it when it has already formed? The agents which have been most employed for this purpose are lime-water, lactic acid, pepsin, and bromine.

In selecting the one that is safest and most efficient, the important fact should be borne in mind that anything which irritates, so as to increase the inflammation of the mucous surface, is injurious. Whatever intensifies the inflammation, evidently augments the thickening and infiltration of the mucous membrane, and increases the area as well as thickness of the pseudo-membrane. It is therefore harmful instead of beneficial. In my opinion the teachings of Bretonneau and Trousseau did immense harm in the fact that they brought into use agents far too irritating to the sensitive mucous surface. Since the pressing danger in croup arises from the obstruction produced by the pseudo-membrane, and by the thickening and infiltration of the mucous membrane underneath, that agent is indicated, if it can be found, which loosens and dissolves the pseudo-membrane, and at the same time tends to diminish or at least does not increase the inflammation of the underlying tissues by its irritating action. Alkalies exert a solvent action on fibrin and mucin, and as the pseudo-membrane consists of the exudate from the blood largely fibrinous, and of epithelium and connective tissue which have undergone degeneration into a substance resembling fibrin (Wagner) or perhaps mucin (Cornil and Ranvier), their employment seems to rest on a sound therapeutic basis. Lime-water slightly turbid, but not so turbid as to clog the point of the steam atomizer, and containing about one and a half per cent. of liquor potassæ, is probably as efficient and useful a solvent as any of the alkaline mixtures. One and a half per cent. liquor potassæ becomes about one per cent. when mixed with steam from the boiler.

By the persistent and timely use of such inhalations as soon as hoarseness appears, croup can, in my own opinion, be often prevented. But we all know how often, notwithstanding our best endeavors, croup occurring in the first week of diphtheria grows hourly worse. In these acute and rapid cases inhalations of the best agents, which physicians have hitherto used, act too slowly to prevent the growth of the pseudo-membrane, and in a few hours it becomes painfully evident that something more must be done or the life of the child is lost. In those many cases in which diphtheria is ushered in with croupous symptoms, and in which, within a few hours, laryngeal stenosis begins to occur, the experienced physician sees at a glance, often at his first visit, that inhalations, however faithfully employed, will be inadequate, and that suffocation, the most painful of all modes of death, will be inevitable, unless other and energetic measures are used.

On the other hand, in the milder forms of croup, in which the exudation has but moderate thickness and forms slowly, inhalations are of the greatest service, and, aided by internal remedies, they not infrequently arrest the disease and save life. The following was such a case: M. J., a girl of two years and five months, took diphtheria on January 6, 1884. I first saw her on the 9th, when a considerable amount of pseudo-membrane covered the fauces. The temperature was but moderately elevated, and a slight discharge occurred from the nostrils. Under the usual treatment the pharyngitis abated, and she seemed to be convalescing until January 14th, when her respiration began to be noisy and embarrassed. On inspecting the fauces a pseudo-membrane was seen upon the aperture of the glottis, apparently dipping down into it. The steam atomizer was employed almost constantly, throwing a spray of lime-water with about one per cent. of liquor potassæ. Each inspiration was accompanied by marked depression of the post-clavicular, epigastric, and inframammary regions, and the respiration was noisy and embarrassed till the 17th, when it began to improve, and the patient was soon out of danger. It will be observed that the croup commenced in the second week or in the declining stage of diphtheria. Had it been earlier, when the inflammation was more active, and the exudation more rapid, in all probability the patient would have perished unless saved by tracheotomy. The slowness of the exudative process afforded time for the action of solvent inhalations. Nearly at the same time that this case occurred, a patient in my practice, who had recovered from croup by tracheotomy, was seized with dyspnœa a month after the operation, when the opening had healed, and a flapping sound could be distinctly heard, produced probably by a pseudo-membrane, which was partially detached. This obstruction, which for a time apparently involved great danger from the dyspnœa which it caused, was removed by the third day under alkaline inhalations. In such cases, in which the inflammation is mild and the exudation at a stand-still, or slow, the benefit from inhalations is most apparent. I am confident that one good result from alkaline inhalations is not fully appreciated by the profession ; I refer to the fact that they render the muco-pus, which collects in large quantity in the bronchial tubes, and is expectorated with difficulty, on account of its viscidity, and the obstacle above it, thinner and more easily expelled.

Now that diphtheria has become so prevalent in this country, and so many children perish of the croup which it produces, it is to be hoped that some more efficient, and at the same time unirritating substance may be discovered for inhalation than those at present in use.

Since my attention has been called to the fact, by Dr. Van Syckel, of New York, that trypsine, one of the digestive ferments secreted by the pancreas, is a rapid solvent of fibrine, he having observed its action in the laboratory of Prof. Kühne, of Heidelberg, I have employed this agent in the usual form of diphtheria in several instances with such result as to encourage the hope that the solvent which we have so long needed has been found. I have never seen pseudo-membranes disappear from the fauces more rapidly than in cases in which the following mixture was applied, every half hour, with a large camel's-hair pencil, whether the good effect was due to the trypsine contained in the extract, or to the alkali, or to the combination of the two :—

Extracti pancreatis (Fairchild's), ʒj ;
Sodii bicarbonat. ʒiij. M.

Add one teaspoonful of this to six teaspoonfuls of water.

Thus recently, in a child of about five years, a thick pseudo-membrane over each tonsil had disappeared by the third day, without apparently any irritating effect from the application. Mr. Fairchild has recently prepared trypsine in a liquid form, in order that its efficacy can be more readily and conveniently tested as a solvent for the membranes in croup ; and Dr. H. D. Chapin informs me that this liquid employed in spray quickly dissolved the pseudo-membrane *in sitû* upon the larynx removed from an infant that perished from this disease. Additional clinical observations will soon determine the value of trypsine as a solvent, and whether, if it be a good solvent, it can be utilized as a spray. That it requires an alkaline medium for its activity renders it compatible with alkaline inhalations.

Internal Treatment—Calomel.—This was long regarded as the most important internal remedy for membranous croup, as well as for diphtheritic exudations elsewhere than in the larynx. In the belief that it had a tendency to prevent the formation of pseudo-membranes, and aided in detaching and removing those already formed, it was in common use until about twenty-five years ago. It was sometimes prescribed for croup in large doses, but more frequently in doses of one-half, one, or one and a half grains, repeated every second or third hour, and often in combination with an opiate, as Dover's powder. However useful a remedy it may be when judiciously employed in croup, as well as in certain other diseases, it fell into disuse on account of its ill-advised employment in diseases which did not require it, its employment often to the extent of producing unpleasant and even dangerous symptoms. When diphtheria was established in this country, calomel was in a few years discarded by most physicians as a remedy for croup, on account of the growing belief that nearly all cases of this disease were local manifestations of diphtheria, and required less depressing and more sustaining measures than mercury. Moreover, it was easy to point out cases in the writings of such masters of the profession as Bretonneau and Trousseau, in which calomel was improperly employed, doing harm by causing not only severe salivation, but also gangrene. Nevertheless cases occurred in those days which seemed to show that this agent properly employed is a potent and useful remedy for croup. One in the Astor House of New York attracted much attention. A child of about two years, stopping at this hotel, had pseudo-membranous laryngitis, with constant and increasing dyspnœa. Prominent physicians summoned to him expressed the opinion that he could not live, when, through the advice of a physician from an inland city who was temporarily sojourning in the hotel, twenty grains of calomel were placed on his tongue. From this time the dyspnœa began to abate, and the patient recovered.

The medical journals from time to time contain reports of cases of croup in which calomel has apparently been beneficial. In the *Med. Record*, July 12, 1884, Dr. J. P. Klingensmith, of Blairsville, Pennsylvania, states that physicians in his locality prescribe calomel in large doses for croup, and with greater success than that achieved by other modes of treatment, and he relates three cases, showing the result in his own practice:—

CASE.—A child aged 28 months took twenty grains of calomel placed on the tongue in the commencement of croup, and afterwards ten grains every hour till the third day when 720 grains had been taken. It was now discontinued, and on the sixth day the pseudo-membrane had disappeared. Recovery was rapid, and without any untoward symptoms.

CASE.—The second patient, aged three and a half years, had been sick forty-eight hours, with a temperature of 102° F. He had a croupy cough, and a pseudo-membranous exudation. Twenty grains of calomel were administered and afterwards ten grains every hour for fifteen hours, so that one hundred and seventy grains were administered. The child, which had previously been restless, fell into a quiet natural sleep. The calomel was discontinued, and a mixture of potassium chlorate and ammonium chloride given in its place. On the fifth day convalescence was fully established, without any unfavorable symptoms.

CASE.—The third patient, a girl of four years, had been sick twenty-four hours, with "high temperature, painful croupy cough, labored respiration, dry skin, flushed face, and some diphtheritic" exudation. Twenty grains of calomel were administered and followed by hourly ten grain doses, till twelve doses were given. No other remedy was employed, and in three or four days the patient recovered.

These appear to have been genuine cases, and that they recovered tends to confirm the belief that calomel does exert a beneficial action on pseudo-membranous inflammations, either diminishing the exudation, or promoting the liquefaction and detachment of the pseudo-membrane.

A mode of treatment commonly accepted and practised by the profession through a long series of years usually does some good, in at least a certain proportion of cases, even if it be abused, else it would not have been likely to gain general acceptance. We know how quickly calomel cures the mucous patches of syphilis, even when they are of large size. These are produced by inflammatory changes in the tegumentary system, and they consist largely of epithelial or epidermic cells. They, therefore, contain elements similar to the pseudo-membrane in croup, but without the fibrin. We know also how readily fibrinous opacities on the cornea yield to calomel dusted on them. We may admit that calomel probably exerts a salutary action either on the exudative process or the pseudo-membrane, without being able to state precisely how it acts. Bouchut says of calomel in his article on croup: "This medicine promotes the expectoration and the rejection of the false membrane." Trousseau believed that the beneficial effects of the mercurial preparations were due mainly to their local action. He states that "wherever they can be applied locally" they "modify most powerfully the diphtheritic inflammation." He dusted the inflamed surface, if accessible, with calomel, or with a powder of the red precipitate, one part to twelve of pulverized sugar. The use of the mercurial collar for the neck in the treatment of croup, employed and recommended by Bretonneau, is familiar to those who have read his memoirs. Professor Jacobi also, who has probably given more attention to diphtheria than any other physician in America, apparently believes that mercury used locally is beneficial in croup, for he has recently recommended inunction with the oleate of mercury upon the neck, whenever the bichloride of mercury administered internally disagrees. It has seemed to me that one or two large doses of calomel administered in the commencement of croup, when there is no decided cachexia, do exert a beneficial action on the course of the disease, as in the following:—

CASE.—R. male, aged three years, began to be croupy, but without any marked impairment of the voice, on November 7, 1884. The mother states that he has had sore throat nearly one week, but without medical attendance. He began to be croupy on November 7th, and his respiration gradually became more noisy and difficult till the evening of the 8th, when I was asked to see him.

His temperature was 99°. The dyspnœa was such that the post-clavicular, supra-sternal, and infra-mammary regions were depressed on inspiration, and his breathing was noisy, but the voice had nearly the usual clearness. The fauces, though red, were not notably swollen, and a pseudo-membranous patch of the size of the nail of the little finger lay over the right tonsil. The diagnosis was, therefore made of mild diphtheria, but with dangerous laryngeal stenosis, probably from the presence of a pseudo-membrane; general condition of the child good. Six grains of calomel were placed on the tongue, and inhalation was ordered by the steam atomizer of the following :—

Liquor potassæ, ʒj ;
Aquæ calcis, Oj.

The record of November 10 states : Resp. 38 per minute, still noisy, but no increase of dyspnœa ; pulse 126 ; temperature in groin 99⅓° ; slight discharge from nostrils ; uses the inhalation almost constantly. From this date the pseudo-membrane and redness of the fauces gradually disappeared, and two days later the patient was out of danger.

The results of the treatment of diphtheria and of the inflammations which accompany this disease are liable to produce an erroneous opinion in regard to the value of therapeutic agents, since cases differ so greatly in type or severity. But the experience of many physicians justifies the belief that mercury and especially calomel employed within certain limits in the commencement of a pseudo-membranous inflammation does exert some controlling action on this disease. That it did much harm formerly when physicians prescribed it as freely as we now employ potassium chlorate to the extent in many instances of increasing the cachexia, and causing mercurialism, should not deter from its judicious use. In the ordinary form of diphtheria I would not advise the use of calomel, or would limit its employment to one or two doses of six to ten grains in the commencement of the disease in robust cases. But in croup, since the danger is not from the cachexia or blood-poisoning so much as from the laryngeal stenosis,which is apt to develop rapidly, that medicine is indicated, and should be prescribed, which most strongly retards the exudative process, and aids in liquefying and removing the pseudo-membrane; provided that it produce no deleterious effect which renders its use inadmissible. Hence it is proper to prescribe calomel in larger doses and for a longer time in the treatment of croup, than in other forms of membranous inflammation, if it fulfil the indication as it seems to in a measure. In my own practice, however, calomel is not prescribed after the first or second day, since I prefer the use of other remedial measures, which are efficient, and are less likely to produce injurious effects.

Emetics.—These have been largely used in all forms of croup, and in catarrhal or spasmodic croup they usually produce marked relief. Formerly emetics were much employed in the treatment of membranous croup, but now that diphtheria has spread throughout the country, and most cases of this form of croup occur in patients suffering from diphtheritic blood-poisoning, depressing emetics as ipecacuanha and antimony have fallen into disuse since they were found to be badly tolerated. In my practice a child of ten years with severe diphtheria and with commencing croupy symptoms, sank rapidly and died between two of my visits, from exhaustion produced by a single large dose of ipecacuanha administered by anxious parents without my advice.

But an emetic gives partial relief to the dyspnœa in certain cases, since it assists in expelling the muco-pus, which blocks up the tubes below the pseudo-membranes, and sometimes portions of pseudo-membrane which are easily detached. If an emetic be employed one should be selected which acts promptly with little depression, and as a rule it should, I think, only be used at the commencement of croup. If after the initial period there be that degree of dyspnœa which suggests its use, tracheotomy is preferable as more likely to give relief, and save the patient. Of the emetics which are admissible in the commencement of croup, sulphate of copper is one of the best. Several years since in one case, in which there were at my first visit dyspnœa, croupy cough, and a pseudo-membrane over each tonsil, and in which I had made an unfavorable prognosis, the parents, observing the good effects of two grains of sulphate of copper, repeated the dose every two to four hours till the following day, and the patient recovered. Such a result however I regard as exceptional. Probably in ordinary cases the best emetic is the yellow sulphate of mercury or turpeth mineral in a powder of two or three grains. The use of this emetic in croup was prominently brought to the notice of the profession by Prof. Fordyce Barker, who administered this agent immediately after being summoned to a case, and he alleges with remarkable benefit to his patients. It has, however, been recently stated on apparently good authority that turpeth mineral when it enters the stomach, although it causes vomiting, is not itself ejected unless in small quantity, so that a considerable share of its action may be through its absorption and like that of calomel.

Internal Disinfectants or Germicides.—The theory which happens to prevail regarding the nature of a disease necessarily influences the treatment. It is now commonly believed that diphtheria is produced by bacteria, and therefore the use of agents which are destructive to micro-organisms is at once suggested as the proper treatment for diphtheria, and for the inflammations which the specific principle of diphtheria gives rise to. Hence sulphite of sodium, sulpho-carbolate of sodium, the phenic acid of Déclat, and chlorine preparations have been administered internally in the treatment of diphtheria, but whether they produce a better result than iron and potassium chlorate is doubtful.

But attention is now widely drawn to the bichloride of mercury, which by common consent is more destructive to micro-organisms, when employed locally, than any other agent that can be safely used. Physicians in search for a remedy that would destroy micrococci in the system and thus remove the cause of diphtheria were naturally led to make trial of this agent in the hope that an antidote or specific had been found. If the bichloride can be safely administered in doses sufficiently large there is every reason to suppose that it will destroy microbes in the interior of the body, as well as upon its surface. If clinical experience show that it can be used in such doses without poisonous effect, it deserves recognition as the specific for diphtheria. If, without injury to the patient, it act promptly enough to kill the microbe before serious organic changes have occurred in the organs, as granulo-fatty degeneration of the muscular fibres of the heart, or nephritis, it would save many lives and become as important a remedy for diphtheria as quinine is for diseases produced by marsh-miasm. But unfortunately we have to deal with an agent long recognized as a deadly poison, and it is a problem yet to be solved whether it would not destroy the patient if employed in doses sufficient to destroy the micrococci. A strong argument in favor of this use of the bichloride was presented to the profession by Dr. Thallon, of Brooklyn, in two papers published in the *N. Y. Jour. of Medicine*, in April, 1884. His argument was substantially as follows :—

It has been shown that the bichloride of mercury destroys the bacteria in a liquid having 20,000 times its weight. Now, if 20,000 grains of blood are disinfected by one grain of the bichloride, 7000 or one pound are disinfected by one-third of a grain. Prof. Flint, Jr., states that, although the proportionate quantity of blood in the system varies in different individuals, it may be assumed that on the average it is in the proportion of one to eight of the entire weight of the body. Therefore one grain of the bichloride would destroy the microbes, and disinfect the blood, in a child weighing twenty-four pounds, two grains in one weighing forty-eight pounds. But if the bichloride can be safely administered to a child in such doses that its system contains one or two grains, still it must be remembered that in diphtheritic systemic poisoning micrococci occur in the lymphatics and the tissues, and therefore a considerably larger quantity of the bichloride is necessary to produce complete disinfection than the quantity which is required to disinfect the blood.

But whether the bichloride, administered internally, is a safe, efficient, and proper remedy for diphtheria must be determined by experience. If it be shown to be such by clinical observations, it should of course be administered in all cases, whatever be the seat of the inflammation. It should be administered in the croup of diphtheria, for if we remove the cause the inflammations will abate or can be more successfully treated.

A considerable number of observations have been made in the last year showing that adults badly tolerate large doses of the bichloride. Thus one-twentieth of a grain administered hourly to an adult with phthisis till seven or eight doses were given each day produced bloody diarrhœa at the close of the third day, when about one grain had been taken. The same result followed in another adult when one-twentieth of a grain had been administered every second hour in the day time only, for four days. In a third patient one-twentieth of a grain given hourly in the day time for five days caused profuse salivation and pain in the gums like that from calomel. A fourth adult patient took one-thirty-second of a grain hourly for eleven hours and then one-twenty-sixth of a grain for seven hours, when griping pain in the abdomen occurred, and liquid stools. (Dr. A. H. Smith.) One adult case only is related in the experiments of Dr. Smith, in which no ill effects followed the administration of one-twentieth of a grain doses of the bichloride though administered hourly in the daytime for eight days. Cases might be mentioned in the practice of other physicians, showing that the bichloride is a dangerous remedy if given in germicide doses in the treatment of adults. In one instance in my practice bloody diarrhœa occurred on the fourth day from the uterine douche used three or four times daily, and fatal cases have been announced in the journals from the douche.

But children seem to tolerate the bichloride better than adults, as they do arsenic. It has been largely used during the last year in New York as a remedy for diphtheria, and especially for diphtheritic croup, and physicians of experience state that more patients have recovered from croup under treatment by the bichloride than from any other medication which they had previously employed. (Jacobi.) The following brief statement of the effects of the bichloride treatment in diphtheria and croup in a few cases in the practice of Drs. Thallon, Armor, Skene, Jacobi, and myself will aid to an understanding of the therapeutic value of this agent in pseudo-membranous inflammations.

CASES.—A child of $6\frac{1}{2}$ years, having diphtheria after scarlet fever, took gr. $\frac{1}{25}$ hourly, most of the time for one week, and subsequently the same dose hourly in the daytime, and two or three times at night, with no unfavorable symptoms; but the urine was increased to 70 ounces. A child of 4 years, having croup, complicating diphtheria, and with urgent symptoms, took gr. $\frac{1}{40}$ of the bichloride every hour and a half to three hours. In five and a half days she took more than two grains, and in one day more than half a grain. Portions of the pseudo-membrane were expectorated, and the patient recovered. There were no unfavorable symptoms from the bichloride.

Of five children who recovered from the ordinary form of diphtheria reported by different observers, one, aged 9 years, took gr. $\frac{1}{40}$ every one and a half hours, and in one day nearly half a grain, till the fifth day, when a little over two grains had been taken. The second child, also aged 9 years, took nearly one-half grain of the bichloride in the first twenty-four hours, and in two days three-quarters of a grain. The third patient, aged $4\frac{1}{2}$ years, took gr. $\frac{1}{40}$ of the bichloride every two hours on the first day, and afterwards at longer intervals. In the fourth case, a child of $7\frac{1}{2}$ years, gr. $\frac{1}{40}$ was given every two hours, for how long is not stated, but the membrane became less on the second day. The fifth patient, aged 2 years 5 months, had a hoarse whispering voice and noisy (guttural) respiration; temperature 105°. The pseudo-membrane appeared over the tonsil in considerable quantity at the close of the second day. The bichloride, gr. $\frac{1}{48}$, was given every second hour alternately with six minims of the tincture of the chloride of iron. Alkaline inhalations were constantly used, and one teaspoonful of brandy given every two hours. The bichloride was administered three days with no appreciable ill effect, and with gradual improvement of the patient.

Although during the last few months the bichloride has been largely used as a remedy for diphtheria and pseudo-membranous croup, in doses like those employed in the above cases, but few instances have been published in which it seemed to disagree. It has, however, in some patients caused diarrhœa, and apparently colicky pains, as in adults, so that it was deemed advisable to discontinue its further use. According to my observation it does not save life, or materially mitigate the intensity of the disease, or the inflammation, if profound blood-poisoning, or grave complications, as nephritis, have occurred when its employment is commenced.

The following cases, among others which have come under my observation, show that the bichloride if administered in grave cases at a late stage is powerless to save life: A child of $3\frac{1}{2}$ years, with malignant diphtheria, took at first the ordinary remedies, such as iron and potash, and when the urine had become heavily albuminous, and the fauces much swollen and covered with a dense and foul pseudo-membrane, the bichloride was prescribed in hourly doses of gr. $\frac{1}{48}$. Two days later death occurred, apparently from the blood-poisoning. Another patient of the same age, and nearly the same history, lived four days under the bichloride treatment. Perhaps better results might have occurred from its earlier use.

Clinical observations will soon determine the actual value of the bichloride in the treatment of diphtheria and diphtheritic inflammations; and if it be a safe and useful remedy, whether its beneficial effects are due to its germicide action, or to the same therapeutic effects as those obtained from other mercurial agents. It may be conveniently prescribed in the following formulæ recommended by Pepper and Thallon :—

℞.—Hydrarg. bichlor., gr. ss.
Tinc. ferri chloridi, fʒiij.
Glycerinæ, f℥ss.
Aquæ, q. s. ad f℥iij.—Misce.
One teaspoonful every hour to two hours.

℞.—Hydrarg. bichlor., gr. ss.
Elix. bismuthi,
Vini pepsini, āā ℥iss.—Misce.
One teaspoonful every hour to two hours.

It does not seem necessary or prudent in ordinary cases to continue the use of the bichloride more than three or four days in large and frequent doses.

Since membranous croup in localities where diphtheria prevails is in most instances a local manifestation of this disease, the same sustaining general treatment is required which is proper in ordinary cases of diphtheria.

The tincture of the chloride of iron, administered every second hour in liberal doses, potassium chlorate, quinine, brandy or other form of alcohol in large and frequent doses, long used in diphtheria as tonics and blood restorers are indicated. Medicines of this kind may be given between those which are designed to correct the exudative process, and aid in removing the laryngeal obstruction, and which have been described above. The diet should be nutritious and easily digested, consisting largely of milk and the meat teas. For those with poor appetite and feeble digestion, peptonized milk, and the peptonized meat juices may often be advantageously prescribed.

Surgical Treatment.—Although the best possible treatment by inhalations and internal medication be early employed and without intermission, yet it is the common experience in all countries that such treatment is in a large proportion of cases inadequate, and that many perish from suffocation unless relieved by surgical interference. We have stated above, that if croup occur at the commencement of diphtheria when the exudative process is active, and the pseudo-membranes form rapidly and abundantly, death is the common result, if medicinal treatment only be employed. But if the inflammation be less intense or subacute, as in the second week of diphtheria, so that there is more time for the action of medicines and inhalations, and if, as is sometimes the case, the stenosis appear to be at a stand-still, without any marked suffering from want of air, resort to surgical measures may be judiciously postponed.

The indications for surgical interference are a gradual increase of the stenosis and consequent dyspnœa, notwithstanding the constant and judicious use of remedial agents, and a manifest suffering from want of air as shown by restlessness of the child, and the expression of suffering in his features, with or without lividity of the surface. We, adults, may have some faint conception of the suffering, which children with acute laryngeal stenosis undergo, when we have severe nasal catarrh and attempt to breathe with the mouth closed, and the paramount duty of the physician to relieve suffering should prompt to a resort to other measures when medicines prove indequate, even if we leave out of account the important object of saving life. When therefore membranous croup is found to be progressive after having been observed and properly treated from six to twenty-four hours, and the child begins to suffer from want of air, the propriety of surgical interference should be considered.

Tubage.—In 1858, Bouchut published a paper in the *Moniteur des Hôpit.* on a new method of treating croup by tubage of the larynx. He employed a straight cylindrical tube nearly an inch long. The tube was introduced by means of a male catheter open at its two ends. Tubage excited some attention and discussion at the time in the Parisian capital, and M. Gros related a case of its successful employment. It was found in experiments on animals that the tube caused ulcerations, and as it did not produce the uniform relief which follows tracheotomy, and was discountenanced by Trousseau, Barthez, and others, it fell into disuse, and was abandoned as a substitute for tracheotomy even by those who at first warmly advocated it. Recently Dr. O. Dwyer, of the New York Foundling Asylum, has devised a tube of about the same length, but differing from that of Bouchut, from having a greater antero-posterior than lateral diameter, and therefore conforming to the shape of the laryngeal aperture. The left index finger, guarded by a broad metallic ring, is carried far back in the mouth of the patient so as to depress the root of the tongue and raise and fix the epiglottis, and the tube is introduced by a curved handle, attached to its inner surface; the handle is detached by a spring. The tube can be readily removed by attaching the handle to the same fastening on its inner surface. Tubing as thus employed usually relieves laryngeal stenosis, and I am not aware that the instrument of Dr. O. Dwyer, although employed in a considerable number of instances, has produced ulceration or other injury of the larynx.

CASE.—On May 21, 1884, during my term of service in the New York Foundling Asylum, Florence ———, 3$\frac{1}{2}$ years, was admitted at the time of my visit, suffering from extreme dyspnœa. The symptoms of acute laryngeal stenosis were so pronounced, such as great depression at the summit and base of the chest on inspiration, restlessness, and the appearance of anguish in the features from want of air, that the child apparently could not live more than two or three hours without relief. The fauces were somewhat hyperæmic, but without pseudo-membrane. The tube was applied by Dr. O. Dwyer, with immediate relief of the dyspnœa, and the expectation of a large quantity of muco-pus. Liquid food was readily swallowed when the tube was present, but occasionally some of it entered the air-passages, provoking a cough. Three hours after the insertion of the tube the axillary temperature was 102°. *22d.* Breathing still easy; axillary temp. 103°; pulse, 130. *23d.* The tube has given complete relief; a small pseudo-membrane exists on each side between the uvula and tonsils. *28th.* The tube was expectorated to-day, and as the respiration remained normal without the tube, it was not replaced. *30th.* Temp. 99$\frac{3}{5}$°; pulse 136, at times as low as 80; has a loose cough. When the tube was worn and immediately afterwards she expressed her wants in a feeble whisper, which could be understood even when the vocal cords were covered by the tube. The voice gradually returned after the expulsion of the tube, and no further treatment was required. The suffering of the patient was quickly relieved, and her life apparently saved by tubage.

The tube when *in sitû* does not produce a cough, or apparently any unpleasant sensation in the larynx. Tubage would in my opinion come into general use as a substitute for tracheotomy, were it not for the fact that the pseudo-membrane in so large a proportion of cases extends beyond the larynx, and the tube fails to relieve tracheal and bronchial obstruction. Since tracheotomy gives equally prompt relief to the dyspnœa, and in a larger number of cases, and enables us to remove the obstruction from the trachea, and to a certain extent from the bronchial tubes through the artificial opening, the almost universal opinion in both continents that it is preferable to tubage or any other surgical measure, has a valid foundation. Usually it is best not to defer tracheotomy, in order to make the uncertain trial of tubage, when the symptoms are so urgent that surgical measures are required.

Tracheotomy.—Since diphtheria has spread so widely, tracheotomy has become one of the most important operations in surgery. Properly performed, and at the proper time with judicious after-treatment, it rescues many children from a most painful death. The details of this operation are given in surgical treatises, but some general remarks relating to it will not be inappropriate in this paper.

Sanné says that the operator should have three assistants, at least one of them a physician. One should administer chloroform, one use the sponge, and the third, a physician, should be ready to assist in handing instruments, ligating vessels, etc. The operation is simple and devoid of danger, or difficult and dangerous, according to circumstances. The younger the child, the greater the danger, other things being equal. The greatest difficulty and risk attend tracheotomy in fleshy infants with thick and short necks, and in patients who have extreme dyspnœa, and are nearly moribund, so that the operator is impelled to hurry on the operation through fear that death will occur before the trachea is opened. The operator should have time for slow and cautious dissection, that he may avoid wounding vessels and other important parts.

The patient to be operated on should be placed on his back on a table covered by a blanket, and a bottle or block about four inches in diameter should be placed under his neck, so that the head is thrown back at an angle of forty-five degrees, and the anterior surface of the neck rendered prominent. Chloroform is then administered. An incision should be made through the skin in the median line one and a half to two inches in length, according to the age, and extending to within half an inch of the sternum. Through the connective tissue to the trachea the dissection should be slowly and cautiously made with the point of the knife, the scissors, and the blunt hooks which are used to tear the connective tissue and draw aside vessels. The tip of the finger occasionally pressed upon the trachea aids in determining its location, and serves to guide the dissection which should always be in the median line. Little cutting is required after the skin has been divided, but when fibres of connective tissue resist the blunt hooks, they should be cut either by the point of the knife or the scissors. A grooved director is also useful in the dissection, since by it the operator is enabled to raise and tear resisting fibres, or detach them from parts underneath, so that they can be more readily divided.

Some surgeons prefer the high, others the low operation. In the high operation the trachea is found nearer the surface, and the vessels in the way are less numerous than in the low operation. In the operation, however, the trachea is usually opened at that point, whether high or low, which is most readily reached and laid bare. When this tube is exposed a longitudinal incision is made through its anterior wall sufficiently long to allow the canula to be inserted. It facilitates opening the trachea if it be held by a tenaculum constructed for the purpose with the hook bent so as to be at right angles with the handle. The length of the incision through the trachea should be about five-eighths of an inch. The canula should not be immediately introduced, but the patient should be made to cough by inserting a pigeon's quill down the trachea into the bronchial tubes. Blood, muco-pus, and shreds of fibrin, if any be present, are expelled through the opening by the cough which the quill produces. The canula is now introduced with or without the aid of the tracheal dilator. The one which is in common use is that devised by Trousseau, with some subsequent improvements. It consists of two concentric cylinders, the external fenestrated, and the disk or plate which supports the tubes is movable upon them.

The result depends to a great extent on the subsequent treatment. The common result is immediate relief to the dyspnœa, but unfortunately in a large proportion of cases the temperature rises about the third day after the operation, and pseudo-membranes begin to form in the bronchial tubes, and in some instances broncho-pneumonia results. Surgeons have endeavored to prevent the formation of membranes in the bronchial tubes after tracheotomy by allowing lime-water to trickle through the aperture into the tubes; but now that probably a better solvent has been discovered in trypsine, a mixture of extractum pancreatis and sodium bicarbonate in water or trypsine in a liquid state as prepared by Fairchild, should be frequently sprayed into the bronchi by the atomizer when signs of bronchial participation in the disease begin to appear. No surgical operation more imperatively requires intelligent and attentive after-nursing than tracheotomy, since the canula needs to be often cleaned whenever obstructed by muco-pus. The febrile movement alluded to above as indicating the extension of the inflammation downwards in the tubes may be in a measure relieved by the application around the chest of one or two thicknesses of muslin wrung out of cool water and covered by oil silk. No certain time can be foretold for the removal of the canula if the patient live. If on withdrawing the inner tube and applying the finger over the end of the remaining canula, the patient breathe easily through fenestra, the laryngeal stenosis has probably so far abated that the tube can be safely removed.

The following is a description of the instruments in the tracheotomy case of one of the most skilful operators in New York City, Dr. Fred. Lange. All of them have small handles like those of dental instruments.

1. *a.* A scalpel, with cutting edge convex, the blade $1\frac{1}{2}$ inches in length, and its greatest width $\frac{1}{4}$ inch. This scalpel is employed in dividing the skin and in the subsequent dissection. *b.* A scalpel of same length, but with narrower blade and straight cutting edge, used for opening the trachea.

2. Two blunt hooks, with the hook straight, $\frac{1}{4}$ inch in length, extending at a right angle from the handle, having a diameter scarcely larger than a carpet needle. The end of the hook is slightly bulbous. A considerable part of the dissection is performed by the blunt hooks which are used in tearing the connective tissue.

3. Three artery clamps, by which bleeding vessels or oozing surfaces are seized, and the instruments with their points attached to the bleeding surface are dropped upon the sides of the neck. They thus aid in drawing open the wound.

4. Tenacula. Two with hooks in line with the handle; two others with hooks at right angle to the handle; the diameter of the curves in the hooks $\frac{1}{4}$ inch. Those with hooks at right angles are employed for transfixing and holding the trachea when it is to be opened.

5. Two grooved directors, one with the end smaller and more pointed than that of the other.

6. A common artery forceps, also forceps with fine teeth.

7. The spring hook of the oculist, employed by him in separating the eyelids; it holds apart the edges of the wound.

8. The tracheotomy tube consisting of two concentric cylinders, described above.

9. Pigeon's quills; these are important for removing muco-pus and fibrinous shreds from the trachea and bronchial tubes. An instance has come to my knowledge in which the physician who assumed charge of the case after the operation attempted to use for this purpose a small piece of sponge held by forceps; he unfortunately loosened his hold, the sponge was drawn in with the breath and immediate death by suffocation resulted. This would not have happened with the pigeon's quill.

Dr. Lange does not stitch the wound by the side of the canula, but leaving it open, dusts upon it iodoform, applies over the iodoform two thicknesses of linen soaked in a bichloride of mercury solution, one part to two thousand, and notched so as to surround and pass under the plate of the canula. The linen is covered by India-rubber gauze. Every hour the linen is moistened by the bichloride solution.

Article II.

A Statistical Review of the Operative Measures devised for the Relief of Pyloric Stenosis.

By Randolph Winslow, M.A., M.D., Demonstrator of Anatomy in the University of Maryland, and Professor of Surgery in the Woman's Medical College of Baltimore; Surgeon to University and Bay View Hospitals, Baltimore.

But few of the ills to which humanity has fallen heir are attended with more distressing symptoms than those produced by stenosis of the pyloric